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ABSTRACT

Second in a series of six monographs on the use of new technologies in the instruction of learning disabled students, the paper offers a descriptive overview of new technologies. Topics addressed include the following: (1) techniques for sharing computer resources (including aspects of networking, sharing information through databases, and the use of electronic bulletin boards and computer conferencing); (2) barriers to centralized information retrieval; (3) instructional uses of videodiscs; (4) videotex application; (5) intelligent computer assisted instruction; (6) the use of peripherals to enhance instruction (including speech synthesis, speech recognition, and nonvocal communication); and (7) computer resource centers. The monograph concludes with a discussion of current barriers to the effective use of technology in the schools. (JW)

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# Existing and Emerging Technologies in Education: A Descriptive Overview

Thomas W. Bakke

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## Introduction

The introduction and application of computer technology has been one of the most dominant trends in elementary and secondary education during the past three years. Yet, there are many questions to be answered concerning its effective use.

The purpose of this paper is to present a descriptive overview of new technologies. We focus first on techniques for sharing computer resources. Nearly all microcomputers can be interconnected. These interconnected systems, commonly referred to as networks, have become quite popular as a means of sharing hardware and software resources and exchanging information. We examine how computers can be used in conjunction with videodisc players and other sophisticated input and output devices. Our discussion then turns to descriptions of videotex and intelligent computer assisted instruction--new technologies on the horizon. Research is cited, when available, to document the uses of these techniques for special education. We conclude with a discussion of some of the current barriers to the effective use of technology in the schools.

## Deciding On a Network

Readers will not find in this paper a general recommendation that networking is a practice that all schools or school districts should adopt. To the contrary, the decision to implement a network should be reached only after a careful review of the factors involved, many of which are mentioned in this paper, and near- and long-term goals that relate to the use of technology. These include:

- the pace at which the organization plans to commit to a substantial use of microcomputer technology
- the assurance that adequate funding will be available to see the implementation plan through
- the timing for investing in network-type technology, where improvements in devices and systems are taking place rapidly

- a cost-benefit comparison between stand-alone and network strategies for providing educational programming.

## The local area network

The local area network is one of two networking techniques. The distinguishing feature of a local area network is its limitation to a moderate sized geographic area, such as a classroom or campus. A second feature is that the microcomputers that comprise the network are physically linked together through a transmission line. The length of the transmission line affects the total cost of the network, the strength and speed of the signals transmitted between computers, and the system configurations that may be used. Most networks used in schools are contained in a single room and often use less than 50 feet of transmission line.

Judd (1984) has suggested that the first step in planning local area networks requires evaluating the following choices:

How many locations are there? (Single site or multi-site)
Will more than one brand of microcomputer be involved? (Single brand or multi-brand)
How will the signal be transported? (Phone line or coaxial cable)
What resources are to be shared? (Program sharing or peripheral sharing)
What storage medium will be used? (Hard disk or floppy disk)

The single site network is the most common application in schools today. Most schools have opted for the single site network because it is far less expensive than having interconnected multiple sites, and because they often do not have enough computers to warrant a multiple site approach. In addition, the most popular network configurations are best suited to single sites. Connell (1981) identifies three basic configurations. They are the star, ring, and bus, as shown in Figure 1. The star and ring configurations are limited by the number of computers that can be networked and by maximum length of cable. The latter factor affects the signal strength and speed of data transmission. The bus configuration, on the other hand, permits unlimited numbers of devices to be connected to the network.

Figure 1

Basic Network Configurations

□ Master controller or multiplexer
● Computers, mass storage devices, printers, or other peripherals

Many network systems allow multiple brands of computers to be connected, but the specific types of computers allowable are a function of whether the network system is of the star, ring, or bus type. In general, costs are bound to increase and complications are more likely with multiple brands. Therefore, the decisions to network or purchase additional computers should be considered simultaneously.

Coaxial wiring (rather than phone lines) is the only feasible way to interconnect microcomputers for the schools, especially in view of the fact that schools have predominantly single site networks. Using phone lines would require the additional purchase of modems (devices that code and decode computer data for phone line transmission) and would also be prohibitive in cost (requiring specialized switching equipment) unless a school had a phone system permitting calls between phones as if each were on an "outside" line.

Probably the most cost-effective use of networks is for sharing expensive peripherals such as printers, graphics plotters, and hard disk data storage devices (Judd, 1984). The use of networks for sharing programs, however, raises special problems. Software vendors have been reluctant to license programs for use in networks because of perceived loss of revenue

associated with such use. Where licenses have been granted, publishers have increased their prices for software in order to maintain a reasonable return on their development investment.

The choice between hard and floppy disk networks is basically one of intended use and cost for schools. While hard disk drives are now substantially more expensive than floppy disk drives, their costs are likely to drop in the near future. The advantages of the hard disk include greater speed, reliability, and memory capacity. Hard disks also last longer than floppy disks. In a floppy disk network the number of original and backup disks required can cost a substantial amount, thus making the hard disk more attractive in the long run. The disadvantages of the hard disk relate primarily to the problems of software licensing. Organizations such as Unicom,* CONDUIT,* and the International Council for Computers in Education (ICCE) are working to reduce these problems. Unicom has arranged for licensing (by educators) of networked software from a variety of publishers for their network system. This eliminates a lot of the uncertainty about cost and availability of software. The ICCE has recently established a policy concerning costs and compatibility of network software. CONDUIT is a nonprofit organization that packages and distributes computer-based instructional materials to schools.

## The remote network

The second type of network is the remote network. This type interconnects computers through the use of a modem (allowing users to dial other computers and database facilities over telephone lines). A powerful central computer (a mainframe) is normally used as a "host" computer, storing information and serving as a central communication point for all the microcomputers in the network. The host can maintain large databases to which the micros have access, as well as "electronic mailboxes" (mainframe computer "files" in which microcomputer users can leave messages for each other). Individual microcomputers can form a network for exchanging information and messages without using a mainframe but the use of electronic mailboxes,

* See Appendix for further information.

"bulletin boards", and databases will be more difficult and expensive. Moreover, only micros with compatible communications software can participate in the network if there isn't a host mainframe. Remote networks have great potential to alter the ways in which people communicate and access information. Three general types of remote networks can be identified: (1) district-based networks that link member schools, (2) long-distance closed memberships, and (3) long-distance open memberships.

The application of the district-based remote network has already been shown as an effective form of information collection and dissemination (Klenow and Rose, 1982; Forman, 1983). Electronic mail allows the district office and individual schools to communicate with each other quickly and easily. Detailed messages can be deposited in respective "mailboxes" to be answered at a later time, eliminating the need to contact a person directly. The host computer can also be used for data analysis and other services usually beyond the capability of the individual school. For example, attendance and scheduling can be handled easily at the local school through the use of a terminal or microcomputer attached to a host. For districts needing these capabilities, mainframe based networks can result in substantial savings in time and money that would otherwise be invested in personnel and equipment.

The two other variations of the remote network system reach beyond the local district, often spanning a given state or the entire country. Paid membership is the basic characteristic of these networks. There are three major advantages beyond those of the district-based network (Raimondi, 1984). First, a structure is provided that links schools and individuals with common interests or concerns. Second, electronic communication is a more cost-effective means of gathering information than is the postal service or the telephone system. Third, access is provided to established databases, informational resources, or human resources.

One of these types of networks is essentially a "closed" (members only) system. Membership is based upon factors such as computer type, user interests or characteristics, or geographical location. These networks are often designed for particular user populations, such as general education or

special education. Members can access public domain (non-copyrighted) software and information databases, exchange information through electronic mail, and receive a newsletter. For example, the Minnesota Educational Computing Consortium (MECC) operates a network for schools within the state of Minnesota although it is now beginning to accept outside members for a fee. Increased interest in state-wide networks has resulted primarily from the spread of management information systems. These networks may facilitate the further collection and exchange of other types of information (e.g., courseware) among states and schools.

Other remote networks are operated on an open membership basis, providing basically the same type of services as the closed network. Unlike closed networks, membership is not restricted to a specific population of users, rather a diversity of users characterizes the open network. The common denominator for these networks is that they share similar interests. For instance, a remote network was established to link schools having microcomputers and videodiscs (McLaughlin, et al., 1983). This network provided a forum for sharing information, resources, and programs for controlling and designing videodisc instructional sequences that were interactive. This type of network may become more common as more schools gain the appropriate equipment and knowledge base necessary for sustained use.

## Sharing Information Through Databases

Probably the most important advantage of remote networks is the access provided to information databases. Databases are one of the largest single sources of information available today and they are growing at a rapid rate. For example, DIALOG Information Retrieval Services, Inc. now has 180 databases. Some 64 of these were added in the past two years, bringing the total searchable records to over 80 million (CHRONOLOG, December 1983). Two new databases, the Computer Database and the Microcomputer Index, should be particularly useful for educators. The former is a collection of articles reviewing the technical features of current and emerging technologies, while the latter contains "user-friendly" articles concerning computer use in the schools.

Neumann (1982) has categorized databases as (1) general information types, (2) bibliographic descriptions, and (3) librarian locator services. First, there are general, "all-purpose" databases, such as the Source and CompuServe. They are easy to use and require little programming knowledge. They can be used to introduce educators and students to the world of telecommunications and information retrieval, and contain a wide variety of general information that can be used to enhance class content in subject areas such as social studies and art. Newly created databases such as the Knowledge Index, lend themselves to these supplementary purposes. All of these databases also provide educator-oriented services. The Source, for instance, offers ED-Line (formally EDNET), a feature of the Education News and Information Network designed to provide educators with the latest updates on federal and state policies and other vital news.

A second category of databases provides bibliographic information. Bibliographic Retrieval Services (BRS), DIALOG Information Services, Inc., and Orbit are major examples of this type of database. A useful service of BRS is Resources in Computer Education (RICE). DIALOG offers Educational Resources Information Center (ERIC) and Exceptional Child Education Resources as two of its seven education files. (Figure 2 describes some of the features of educational networks.) These databases are comprehensive sources of information and are more difficult to learn to use effectively. The information tends to be technical and scholarly. For instance, a teacher may wish to do a literature search for recent research on a particular learning disability, or may be interested in how schools are evaluating software. Presently teachers acquire this type of information through some established centralized process (e.g. the county office) which may discourage the teacher from even requesting it due to the length of time before delivery. The literature indicates that information retrieval will become a common and inexpensive service in the future, permitting such information needs to be met more at the local level. As this occurs, it also seems likely that students, particularly at the high school level, will also make use of these resources.

Figure 2
Telecommunication Services Designed for Educators

| Service | Audience | Features |
|---|---|---|
| TechNet (formerly BESTNet)<br>AECT<br>1126 16th Street N.W.<br>Washington, D.C. 20036<br>(202) 466-4780 | General Educators<br>Media Specialists | Electronic Mail<br>Bulletin Boards<br>Computer Conferencing<br>Databases |
| BRS Colleague Educator<br>(formerly SPIN)<br>Bibliographic Retrieval<br>Services<br>1200 Route 7<br>Latham, NY 12100<br>(518) 783-1161 | Regular Educators | Electronic Mail<br>Bulletin Boards<br>Databases |
| Computer-Based Message System<br>for Vocational Education<br>National Center for Research<br>in Vocational Education<br>Ohio State University<br>1960 Kenny Road<br>Columbus, OH 43210<br>(800) 848-4815 or<br>(614) 486-3655 | Vocational Educators | Electronic Mail<br>Bulletin Boards |
| DCI-DeafNet<br>Deaf Communications Institute<br>P.O. Box 247<br>Fayville, MA 01745<br>(617) 872-9406 (voice & TDD) | Hearing-Impaired<br>Individuals | Electronic Mail<br>Bulletin Boards |
| ED-LINE (formerly EDNET)<br>National School Public Relations<br>Association<br>1801 North Moore Street<br>Arlington, VA 22209<br>(703) 528-5840 | School District<br>Offices | Electronic Mail<br>Bulletin Boards<br>Databases |
| Electronic Information<br>Exchange System<br>New Jersey Institute of<br>Technology<br>323 High Street<br>Newark, NJ 07102<br>(201) 645-5503 | Educators<br>Researchers | Electronic Mail<br>Computer Conferencing<br>Databases |

(cont'd)

Figure 2
Telecommunication Services Designed for Educators (cont'd)

| Service | Audience | Features |
|---|---|---|
| SpecialNet<br>National Assn. of State Dirs. of Special Education<br>1201 16th Street, N.W.<br>Suite 404E<br>Washington, DC 20036<br>(202) 822-7933 | General Educators<br>Special Educators | Electronic Mail<br>Bulletin Boards<br>Databases |
| Handicapped Educational Exchange (HEX)<br>11523 Charlton Drive<br>Silver Spring, MD 20902<br>(301) 593-7033 (computer access phone) | Special Education<br>Hearing-Impaired Individuals | Bulletin Board<br>Databases |
| Living Bulletin Board System for Educators<br>Far West Laboratory<br>1855 Folsom<br>San Francisco, CA 94103<br>(415) 565-3000 | School Districts | Bulletin Board |
| Dialog Information Services<br>3460 Hillview<br>Palo Alto, CA 94304<br>(800) 227-1960 | General Education<br>Special Education | Databases |
| CompuServe<br>5300 Arlington Center Boulevard<br>Columbus, OH 43220<br>(614) 457-8600 | General Educators | Electronic Mail<br>Bulletin Board<br>Computer Conferencing<br>Databases |
| The Source<br>Source Telecomputing Corporation<br>1616 Anderson Road<br>McLean, VA 22102<br>(703) 821-6660 | General Educators | Electronic Mail<br>Bulletin Boards<br>Computer Conferencing<br>Databases |

Adapted from: Sharon L. Raimondi (1984). Electronic Communication Networks. Educational Technology, 24(2), p. 40.

Databases in the third category serve the primary purpose of assistance to librarians. Through this service, librarians are able to determine where a book is located and then to make provisions for borrowing it. An outgrowth of this development is that libraries are putting their collection into on-line databases. Stanford University, for example, recently implemented the Socrates system which allows students free searching of all the university's libraries through terminals on campus. Non-campus users can access Socrates through their data processing accounts with the university's computer center. Although these systems are not typically found at elementary and secondary levels now, their use may reach these levels in the future.

## Using Electronic Bulletin Boards and Computer Conferencing

The previous discussion centered on the filing and accessing of information stored centrally in databases. Characteristically, such centralized databases are established because it is not feasible to maintain the entire file locally. The assumption is that the resident information simply "sits and waits" until it is (selectively) called forth. In contrast, electronic bulletin boards and computer conferencing involve the active participation of information providers and users. Bulletin boards allow the temporary posting of announcements and messages to be read by others. Computer conferencing allows a dialogue or multi-user exchange of information on a real-time basis.

Computer conferencing typically involves persons who have a need to exchange information rapidly and sometimes continuously. In the business world such an application might take place between a head office and branches, with the branches pooling information to form a joint plan, compare projections and results, accomplishing tasks of importance to all.

In education, a parallel could be drawn to remote higher-education instruction (e.g., the Open University) where an instructor might simulate a classroom discussion with several students responding through their terminals. In educational conferencing, then, the participants are apt to be on-line at the same time, with ample opportunity for interaction. Cross (1983) points out that several simultaneous conferences can be held and the

information from each can be stored for later retrieval--in one sense providing a kind of note-taking function for the participants.

Electronic bulletin boards are a growing specialized use of the network concept, closely related to teleconferencing. As of September 1981 there were over 300 bulletin boards operating in North America (Ragsdale, 1982). Unlike traditional uses of databases where information can usually only be retrieved, bulletin boards offer the user the opportunity to contribute information to the database. This unique method for sharing information has the potential to radically affect communication among schools. A recent search indicated nearly a dozen educational bulletin boards with as many as 20 sub-boards dealing with different topics, all available from one central service (Edwards, 1983).

SpecialNet, a national electronic mail/bulletin board devoted to the handicapped, offers numerous specialized educational bulletin boards as well as access to databases (Edwards, 1983). Some of the bulletin boards available through SpecialNet include Multi-handicapped, Vision, Deafness, Computer, and Edutech for computer applications in special education (which is managed by Education Turnkey Systems, Falls Church, Va.). The Handicapped Educational Exchange (HEX) is a specialized bulletin board that serves two purposes (Barth, 1982). HEX serves as a clearinghouse for information on technology for the handicapped and also provides a system access facility specifically designed for the deaf or hearing impaired. The data on HEX are available in three forms: information files, data files, and messages. Files can be retrieved for local use, and saved as microcomputer files. New information can be transmitted to the host computer by users and entered for use by others by the system operator.

## Barriers to Centralized Information Retrieval

In education, most information retrieval occurs at the county level (rather than the school level) due to limited availability of equipment and trained personnel. However, the diffusion of computer technology and the ease of using databases is changing this situation. But before substantial school-level use of databases occurs, several other barriers must be overcome.

Costs are one barrier associated with database use. There is usually a subscription fee, which may range from $20 to $200 (Sandy and Evans, 1981). In addition, there may be monthly charges. The major costs include on-line connect time, printing charges, and long-distance telephone costs. The first two costs are dependent upon which particular database is accessed. Typical prices for educational databases, such as ERIC, are $25 per hour and 10 cents per printed record. Long-distance telephone rates are significant cost factors. The use of discount telephone services such as WATS lines, TymeNet, or Telenet can help offset these costs. Preplanned database searching strategies, because of their on-line efficiency, are the most effective means of lowering costs.

Educators feel they cannot justify the cost of new technologies. They have indicated a preference for local resource centers, explaining that they are familiar, free and convenient. A closely related problem is the limited awareness among educators of existing electronic communication facilities and opportunities. Many networks and databases are often underutilized because the target user population is either unaware of them or lacks adequate information for finding out about them. This points out the need for exploring ways in which this information can be more effectively disseminated.

The major barrier to use of electronic communication technology is reluctance to change (Edwards, 1983; Ragsdale, 1982). Change in the education system has always been slow due to the pervasiveness and permanence of established practices. Even educators who try networking often go back to conventional means of meeting their information needs, once the novelty of networking wears off. The success of networking is dependent in large measure on whether the applications that are developed are seen as useful in serving the handicapped.

## Instructional Uses of Videodiscs

Videodisc technology is a relatively new and very flexible educational technology. Record-like in appearance, these high density storage devices offer the user audio, graphic and pictorial storage capability (both still

and motion) and interactivity for instructional purposes. Despite its enormous potential, the technology is too new to have gained widespread acceptance. In this section we will discuss the major strengths and weaknesses of videodisc technology in its present state.

What makes the videodisc so appealing is its ability to store large amounts of information that could not otherwise be effectively or efficiently stored (Schimpa, 1981; HumRRO, 1982). Each videodisc can store approximately 100,000 "frames" or pictures of information. The frames can be retrieved in any order, with a maximum search time of about three seconds, and average search times under one second.

The videodisc is a durable medium and inexpensive in relation to the amount of data stored. The cost of videodisc players has dropped appreciably as the industry has established itself. The price of discs is now competitive with film, slides, and even diskette programs. But the important fact is that the disc is especially long-lasting, unlike film or transparencies. Highly resistant to damage by scratches, dust, or spills, videodiscs do not require special handling care.

A unique feature of the videodisc is the combination of high quality sound and graphics. So far the microcomputers used in the schools have not been able to generate anything approaching the quality of sound or graphics of the videodisc. The programming effort required to produce a comparable sequence of sound or video, moreover, would be prohibitive. The high quality of reproduction (both sound and images) presents a major opportunity for improving the quality of instructional materials.

Videodiscs can be used to provide individualized self-paced instruction. An "intelligent" videodisc player can be created by controlling the videodisc player through a microcomputer. Instructional sequences can be designed that take full advantage of the capabilities and content of the videodisc. Sophisticated software can be used to control program branching and/or chart student progress. Such a system has been shown to be appropriate for special education classes (Allard and Thorkildsen, 1981; Thorkildsen, Allard, and Reid, 1983).

Graphics tablets and touch-screens are alternative input devices that can be used with videodisc players. For example, the Interactive Videodisc for Special Education Technology Project (IVSET) at Utah State University has demonstrated the use of a touch screen in providing CAI for mentally handicapped students (Thorkildsen, 1982).

Kearsley (1981) has summarized the three major findings of instructional videodisc projects. First, we have learned that instructional design of videodiscs involves close coordination of individuals with experience in interactive computer programming and educational video mediums. This interaction is necessary if the instructional potential of videodiscs is to be realized. The theoretical frameworks necessary for instructional use of interactive videodiscs are just now being developed (e.g., Bunderson, Gibbons, Olsen, & Kearsley, 1981). There is general agreement that interactive videodiscs should be designed for easy user control. What is needed now are videodisc authoring systems and input devices that allow the students and teachers to easily design and control the interaction. The complexity of interactive programming is one of the deterrents to rapid expansion of videodisc systems (Hiscox, 1982). McLaughlin, et al. (1983) found that school staff had too little expertise and insufficient time to produce videodisc courseware in a programming language.

A second finding is that only tentative conclusions about the instructional effectiveness of interactive videodiscs can be drawn at this time. As recently as 1982, it was estimated there were only 100 to 200 videodisc players in the primary and secondary schools (Withrow and Roberts, 1982; Holloway, 1982). Nevertheless, preliminary results indicate that teachers have found the videodisc medium effective (Daynes, Brown, & Newman, 1981). Teachers believe it has great potential as an educational tool (McLaughlin et al., 1983; Glenn, Kozen, and Pollak, 1984). The unique capabilities of the videodisc and how it is utilized has precluded useful comparisons with other instructional techniques. It is not really a matter of comparison of effectiveness that is important, but rather how this technology can be applied creatively and efficiently to solve current needs.

The cost of videodisc systems has been one of the major obstacles to its widespread use. However, these costs are rapidly decreasing. For example in 1983, a typical videodisc player costs $500 to $3,000 and videodisc interface cards necessary for use with a computer costs $450 to $700 (Troutner, 1983). New videodisc players were marketed in 1984 for less than $500. Likewise a videodisc interface cable with software for use with the Commodore 64 has recently been announced for only $50. Videodiscs are also relatively expensive at this time due to the limited number of videodisc players in the schools. Their price is likely to drop as videodisc players and their applications (and thus the market) in the schools increases.

The low cost of purchasing videodiscs, as opposed to designing or producing them, makes their future very promising. Designing the instructional sequences to be used in a videodisc can be extremely expensive due to time and personnel costs. However, the cost for a disc can be as low as $10 to $20, far less expensive than videotape or film.

The lack of available instructional videodiscs is currently a limiting factor. Most of the industry's effort has been concentrated on the entertainment field. Entertainment discs are fairly easy to produce because the subject matter has already been developed. It is therefore a simple matter of mastering discs and marketing. Videodiscs for educational uses are much harder to produce. Their development has been and will continue to be slow due to the complexity of designing sound instructional applications, and the associated costs. Close cooperation between educational and industrial organizations helps to minimize cost. The lessons learned in computer-based software development should prove valuable in this regard.

Heath (1981) has identified four alternative videodisc systems: reflective, transmissive, capacitance electronic disc (CED), and video high density (VHD). They are not interchangeable in use.

The first two of these systems are referred to as laser systems because they use a laser beam, rather than a stylus, to "read" the information on a "grooveless" videodisc. The life of videodiscs used with the laser

videodisc systems is indefinite because there is no stylus to contact and wear on the disc surface. Both systems provide access to 54,000 frames of information per disc side. Other features include random access to specific frames, programmability, fast-forwarding and variable playing speeds, including slow motion, and single frame stepping (forward or reverse).

There are two significant differences between the reflective and transmissive optical videodisc systems. The reflective system bounces its laser beam off a mirror-like disc surface. The transmissive system, which does not use a mirror-like disc, can access frames on both sides of the disc because it transmits its beam through the top surface to reach the bottom. The result is that the disc does not have to be manually flipped, and instructional sequences can be designed to use any frame on either side. Laser reflective videodiscs, however, are more durable and resistant to scratches and dirt than are the transmissive discs. The durability of the reflective videodisc make it particularly well suited to the school environment. This is one reason why the reflective laser system had been more widely used in education.

The CED system uses a diamond stylus to track a grooved videodisc. This makes the player and the disc significantly different from the laser videodisc systems. The CED is a relatively inexpensive system; however, it lacks most of the flexibility of the laser systems. For example, it has very limited frame searching capability, and it has only about half the number of frames per disc side as the other three systems. In particular, the lack of programmability make the CED unsuitable for instructional purposes that require branching in a program.

The VHD videodisc system employs the same audio/video signal measuring concept as the CED but uses a flat stylus on a groveless disc. This design allows the VHD to approximate many of the features of the laser videodisc systems. For example, random access of frames can be used, although not as precisely. Slow motion and fast-forwarding take longer than the laser system but it is able to provide 60 minutes of play per side as compared to 30 minutes for the reflective laser disc system.

The improvements that would make this technology more attractive to schools are now under development by videodisc equipment manufacturers. These include discs that can be erased and re-recorded, and sound that can be played while the video detector is hovering over, and showing, a single still-frame. As players are now manufactured, they have no recording capability, and sound is only available during normal playing speeds, although the videodisc player can be set to show video material at still-frame and variable playing speeds. The option of having extended sound during still-frame is now available through specialized add-on peripheral devices, and should soon be available on low-cost consumer and industrial players. This will greatly improve the disc's range of applications.

Finally, a needed service for schools is a videodisc library. This service could be incorporated into existing local or regional resource centers to identify and evaluate potentially useful discs, disc authoring languages, and programs. However, the viability of a library approach will depend upon how videodisc publishers treat the issue of permitting multiple users to share a single disc program. A number of publishers do not now allow their discs to be used in schools as they intend them for sale to individuals for their private use.

## Exploring Videotex Applications

Similar to on-line data bases discussed earlier, videotex offers the user access to remote sources of information. Information can be transmitted and received through optical fiber, cable television, telephone line (via computer modems), broadcast television, and broadcast FM radio. Standard television monitors are typically used to display information. Perhaps the best feature of evolving videotex systems is the ability of the user to simultaneously manipulate text and graphics interactively. Furthermore, videotex is easy to use and the necessary software is standardized and contained within the system. Although these systems are just emerging, their potential as an educational resource is clear (Levine, 1982). Program captioning is already an available feature, useful for the hearing impaired. Captioning provides a text transcription of the aural component of a television program. Captions are displayed at the bottom of the viewer's

television screen. "Decoders" which display captions can readily be purchased in most parts of the country.

In this discussion, we will use the term videotex as a generic term to apply to both one-way information services (teletex, videotex) and two-way services (videotex, viewdata, cabletex).

In a one-way system, hundreds and even thousands of "pages", or screens, of information are continually transmitted or broadcast through the airwaves. With the proper equipment, a user can select a particular page for viewing. The television then waits for that page to appear in the information stream, picks it out, stores it, and displays it on the screen (OTA, 1982).

The two-way videotex system is more sophisticated, requiring communication between the equipment at the information source, and equipment operated by the viewer. In this case, the viewer requests a specific page from the source and then waits for that information to appear on the screen. The videotex system is usually used in conjunction with cables or telephone lines but can also be accessed through a broadcast network. (For a more detailed discussion of the recent developments in videotex, see BYTE, July 1983.)

Tydeman, et al. (1982) describe the evolving nature of videotex technology. Information retrieval, messaging, and computing are three of the five basic classes of information services of videotex systems. According to Tydeman, the key differences between the different videotex systems, from the user's perspective, are the quality of graphics and the average waiting time per frame of information.

It is important to emphasize that videotex and microcomputers are not alternative technologies; they are complementary. Not only can computers be used as videotex terminals, they can also process information once it is accessed. As with computer technology in general, cost and ease of use are the factors that will determine the future of videotex systems (see for example Miller, 1983; Malloy, 1983a & b).

## Incorporating Intelligent Computer Assisted Instruction

Recent research in educational computer systems has made intelligent computer assisted instruction (ICAI) an area of considerable promise and interest. ICAI systems, a type of "expert" system, are "intelligent" because of their ability (a) to interact with the user through a natural language, (b) to make inferences about the user's input, and (c) based on these inferences, to modify their own responses. Rather than being programmed to follow step-by-step procedures to solve a problem, the expert system incorporates information supplied by a user to add to its built-in base of information about a topic. Decision rules guide this acquisition and interpretation process. ICAI systems are being developed with capabilities to "understand" what is being taught, what the student is or is not learning, and why a student may have made a mistake.

### Components of ICAI systems

ICAI systems have three components which correspond to the three main components of any instructional system, namely the content to be taught, the instructional strategy to be used, and a mechanism for understanding what the student has or has not learned. These are referred to as the expertise, student, and tutoring components (Roberts and Park, 1983).

The expertise component consists of a base of information that is to be taught, and procedural knowledge used to solve problems, generate questions, and evaluate student responses.

The student component is a method of representing the student's understanding of what is being taught. This component is used to make hypotheses about the student's responses and performance strategies so that errors can be pointed out, explanations can be made and suggestions can be given for corrective action.

The tutoring component specifies how the system should present information to the student. This component is responsible for the actual communication with the student. As such it integrates knowledge of natural

language, teaching methods, and subject matter. The strategy in the tutoring component is based on one of the following methods (Roberts and Park, 1983): (a) a diagnostic or debugging approach by which the system generates problems for the student and analyzes the responses in order to debug the student's misunderstanding; (b) the Socratic method of questioning the student in such a way that he or she will think critically and thereby modify his knowledge; and (c) a coaching method that engages the student in an activity to encourage skill acquisition and general problem-solving abilities.

## Evaluation of ICAI systems

The relatively recent exploration into the development of ICAI systems indicates some of the potential for using the computer to improve the instructional and learning processes in education. Moreover, this potential is likely to be further developed as ICAI systems become more available and are implemented on microcomputers in the schools.

One of the major potentials of ICAI derives from its ability to separately focus on factors associated with student characteristics, instructional strategies, subject matter, and the nature of student-teacher communication that should be taken into account in designing instruction. Because these four areas parallel major efforts in traditional instructional research, there is the possibility that ICAI research will inform and improve traditional instructional research and vice versa.

A second potential of ICAI is in improving the individualization of instruction. Kearsley, et al (1983), in reviewing the past two decades of computer-based instruction projects, concluded that we know relatively little about how to individualize instruction. Despite the volume of computer-based materials, they remain crude in nature; we have not achieved a sophisticated form of individualized instruction.

A third potential of ICAI is that it may greatly increase knowledge about the nature of computer-student interaction (Kearsley, et al. 1983). By its very nature ICAI allows for more indepth exploration and confirmation

of the learning process through its ability to characterize or classify successive student responses. Therefore instructional materials can be used in more precise and predictable ways. The natural language used in ICAI interaction is particularly valuable in facilitating information flow between the student and the program (Feurzeig, Horwitz, and Nickerson, 1981).

One major limitation of ICAI systems is the labor intensive effort required for courseware development. This translates into a high cost of the final product. Work aimed at developing generic expert systems may help to reduce this cost. A second problem involves assumptions of about how people reason. We do not currently know enough about this process, and consequently expertise components and student components used in ICAI systems may not be appropriate for all students. The hardware and software requirements for ICAI systems limit their practical application in the school. Until recently, microcomputers have not had the speed and memory capacities necessary to implement ICAI systems. Consequently, most applications have been designed for minicomputers or mainframe computers. However, an abbreviated version of the BUGGY program, developed by John Seely Brown, has been implemented on the Apple II microcomputer (Feurzeig, et al., 1981). The BUGGY program utilizes a student's inputs to identify his or her misunderstanding about arithmetic rules and procedures.

So far ICAI has largely been applied in experimental situations. In addition to BUGGY, Kearsley, et al, (1983b, p. 91) has identified some of the major programs contributing to ICAI development as follows:

- SCHOLAR, a geography tutor
- SOPHIE, a tutor for electronics
- WHY, a coach for tutoring meteorology
- WEST, a coach for game playing

## Using Peripherals to Enhance Instruction

One of the most interesting and wide-ranging developments in computer technology has been the proliferation of peripheral devices for the computer. New ways of interacting with the computer and instructional materials have important consequences for all students, but especially for the learning disabled, speech handicapped, and physically impaired. Certainly, sharing via networks will be limited if the network only works with some students and not others. An examination of some of the most significant innovations of this technology are discussed below.

### Speech synthesis

There are numerous potential advantages and applications of speech synthesis with microcomputers. For example, students can be introduced to the computer without the requirement of keyboarding skills. This may be particularly important for students with limited reading skills, dyslexia, or visual impairments. Ginther (1983) indicates other significant contributions: (1) oral instructions can supplement visual directives; (2) the relationship between written symbols and their phonetic counterparts can be explored by students; and (3) students also can explore the intricacies of language and communication.

Specific features of these devices offer considerable control over output, depending upon the implementation (Ginther, 1983; Harvey, 1983). The user may, for instance, control the inflection and pitch of single syllables or complete phrases. Instructions may be included to direct inflection so it is appropriate, given punctuation symbols (e.g., upward inflection for a quotation mark). The synthesizer can be further directed to spell out text letter-by-letter or even to sing words. The pitch of voice is another variable. In addition, text can be translated on a word, phrase, or line basis and a delay can be programmed in to accentuate the effect.

Three types of voice synthesizers exist (Harvey, 1983). The simplest systems come equipped with established vocabularies of words, phrases and

suffixes. These systems vary in content and size. An example of this type of synthesizer is the Phonic Mirror HandiVoice, a portable battery-operated device with a 1,000 word and phrase vocabulary which the user accesses by entering a three-digit code on a numeric keypad (Bennett, 1982).

A more versatile system uses phonemes and allows the user to add new vocabulary to the system by programming or by typing text in via the keyboard. Hence, this system is called text-to-speech. Instead of storing a finite body of words, speech is generated by manipulating phonemes within the system. Thus the size of the vocabulary is limited only by the storage capacity of the computer. The Talking Typewriter allows handicapped students to enter messages through the keyboard and then translates them directly into English speech. The Type'-N-Talk, the Inter-Talker, the Echo, and the Microvox are additional examples. These systems range in price up to $400, making them affordable items for many school applications.

Harvey (1982) describes the third type of system as one combining standard vocabulary and phoneme manipulation.

Text-to-speech translation can be quite expensive. Stoffel (1982) notes that the price increases with the sophistication of the translation algorithms, synthesizers, terminal/computer and speech parameter control variables. Essentially, the end product is a much higher quality of speech. Some synthesizers can be ten times as costly as those described above. Systems costing over $4,500 include VERT (Verbal Emulation in Real Time), Total Talk, and FSST-3 (Free-Scan Speech Terminal).

Speech recognition

Recognition techniques allow individual voices to be used for input. The possible applications for education are numerous. Harvey (1983) lists four application areas: (1) analysis of spoken learner input; (2) feedback based on spoken responses to questions; (3) data entry without keyboard skills; and (4) control of computers with spoken commands.

Despite the exciting nature of these possibilities, enthusiasm must be tempered with the understanding that true speech recognition (i.e., actual complete words, rather than sounds or phonemes) is a far more difficult engineering task than producing speech from text. In a recent review of some theoretical and practical aspects of this emerging technology, White (1984) describes speech recognition as an engineering Gordian knot. White cautions not to expect a breakthrough in this technology, emphasizing that progress will be evolutionary, not revolutionary. Only two of nine systems that he reviewed had vocabularies over 150 words. Four cost less than $6,000. Only one under $15,000 had even a limited capability of continuous speech recognition (as opposed to isolated word recognition).

A number of low priced alternatives that recognize simple and unique acoustical signals have received favorable reviews. These systems have extremely high recognition rates, although they must be "trained" to recognize the verbal commands of particular individuals. The Cognivox VIO-1003 and The Shadow/VET (Muller, 1982) have been shown to be effective and easy to use applications for the Apple II. Markowsky, Youdin, and Reich (1981) and Songprachakkul (1980) have also described speech recognition systems for the TRS-80 and Apple II capable of recognizing 32 different vocalized inputs by users. This feature makes possible voice activated typing, thus facilitating a high level of student-computer interaction.

Nonvocal communication

While many creative applications for peripheral devices have centered on vocal communication, there is evidence of growing support for other applications. A recent study by Johns Hopkins University found out that 22 of the 97 best entries in a national search for creative computer applications for the handicapped were designed for nonvocal communication (Hazen, 1982). Often these devices are used in combination with speech synthesizers and other peripherals.

For example, the use of graphics tablets to provide direct, yet flexible, interaction with microcomputers has been well demonstrated. Recently significant improvements in their capabilities, adaptability and

pricing have led to their wider use. The KoalaPad Touch Tablet and VersWriter are two examples of low-cost, dependable, and versatile touch-sensitive input devices that can be used for graphics or to enter data or responses (Adams, 1983-84).

Domasco and Foulds (1982) have described in detail how specially designed touch-sensitive tablets, in combination with a voice synthesizer and the Panasonic Hand Held Calculator, can be used by the physically handicapped. The basic approach is to overlay a maximum 12 by 12 matrix of characters, words, or letter clusters onto the tablet. The user then selects the appropriate array, which can be accomplished through the use of fingers, touch sticks or other objects. A certain level of motor control is therefore required. Software included with the tablets is used to control the selection of layouts that include targets and even arrays of targets with mixed sizes and shapes.

Another related device, Minspeak, is currently under development and is designed for those students unable to express themselves through speech or hand signs. Minspeak is a keyboard that facilitates the creation of complete sentences without selecting letters, phonemes, or words. Baker (1982, p. 186) explains the concept:

> The coding technique uses sequence to define context, thus exploiting the human mind's ability to process semantic information. Easy-to-understand symbols on each key represent ideas. The meaning of each key image changes according to the sequence in which it is hit. By combining these symbols, whole spoken sentences can be generated. The simplicity or complexity of the symbols will depend upon the needs and abilities of the user.

In a similar vein, software has been designed that produces these arrays on the screen while input can be made through a variety of technologies. The Alpha Menu program (James, 1980) has been used extensively in schools with disabled students. Among the input devices that have been used effectively by disabled students are joysticks, light pens (Joiner, et al., 1980), a variety of switches operated by the head, arm and chin (Winters, 1978). A device called a "mouse" can be moved in four directions on a horizontal surface until a specific point is reached. This permits selection from the alternatives shown on a computer display screen.

## Developing Resource Centers

Computer resource centers (school-based, regional, and national), are increasing in number and popularity. Although the national resource centers are more well known and established, regional and school-based centers are beginning to gain a share of the limelight. Designed specifically to serve the local community, although not limited to that domain, these centers help in the diffusion of microcomputer technology in the schools. Principally, these centers are beginning to play a central role in providing training, software, and information.

One that started locally but grew to be a national resource is SOFTSWAP, a joint project of the Microcomputer Center of the San Mateo County Office of Education and Computer-Using Educators (CUE), located in Redwood City, California. SOFTSWAP receives donations of public-domain educational software and evaluates and refines the programs. Donation of a program entitles the donor to receive any SOFTSWAP disk in return. SOFTSWAP thus operates much as a software clearinghouse.

Using this approach, other local resource centers can provide schools with easily accessible and free source of software that is much needed. Educators can also use these centers to preview software to determine its quality and applicability for their needs. Many centers have been expanding their services to provide various types of teacher and student training. Additional services offered at some centers include providing advice on the location, cost, and evaluation of hardware and peripherals for handicapped students.

On a regional scale, California recently established 15 Teacher Education and Computer Centers (TECC). The TECC system was established to train teachers in the elementary and secondary schools to improve math, science, and computer education. The actual form each center takes varies. Region 8 Director Shareen Young explains: "We look at how we can assist the current staff in each county and help them provide the basic services their own teachers need. And we help organize the counties so they can share resources" (Waldrop, 1983). Although TECCs are recent additions to the resource community, they promise to be important ones in California.

## Factors Affecting Innovative Uses of Technology

If schools are to maximize the educational opportunities of the new informational technologies, current methods of resource sharing will have to be enhanced and new methods will have to be developed. In fact, the central concept of the emerging information society is one of sharing and exchange. However, there are some substantial barriers to resource sharing that first must be surmounted. Some of these barriers are likely to be temporary. Others, grounded in the structure of the educational institutions themselves, will be more difficult to overcome. The impact of new educational technology will be determined by how we address these problems.

An obvious impediment to resource sharing is the lack of general awareness of how available technologies can be used. Most teachers think of computers as a resource to assist the traditional educational process rather than as a tool to create new ways of learning. This is evidenced by the ways in which computers have been used to date. The predominant use of computers has been and continues to be for drill and practice. Much of the additional use of computers has been to teach programming skills. Active efforts to broaden awareness of the additional uses of computers must be made.

A second impediment is related to the emerging state of new technologies. Because the technology is so new, many schools have only recently begun to acquire computers and peripheral equipment. The processes for acquiring and using computers in the schools has yet to be incorporated into the formal school planning. For most of these schools, the first implementation objectives will focus on commonly perceived needs (such as using computers for teaching computer literacy, CAI and programming) rather than on creative plans to meet the special and unique needs of each district.

Other barriers present more formidable obstacles. Pogrow (1983) has identified the following as the most prominently cited barriers:

(a) inadequate capital resources to purchase equipment;
(b) few incentives for teachers to use computers;
(c) lack of computer literacy among teachers and administrators;
(d) shortages of teachers with technical backgrounds;
(e) shortages of new educators with technical backgrounds;
(f) political resistance by unions;
(g) lack of incentives or profit opportunities for industry;
(h) inadequate protection against software piracy;
(i) lack of quality pre- and inservice training to personnel in the application of technology; and
(j) lack of knowledge about the uses and importance of technology on the part of the government officials.

It is still too early to predict how each of these problems will affect the diffusion of technology. However, a recent RAND Corporation study reported difficulty in locating computer-skilled teachers to interview--apparently as their expertise develops they become candidates for entry into the business world in computing.

Three factors that appear to be critical are the cost of hardware and software, reluctance by educators to embrace technological change, and availability of software. Economic problems are particularly vexing since the fiscal resources for schools are declining and new technologies require new investment. Equipment costs remain relatively high despite the projected continued drop in the price per unit. Schools are preoccupied with ways to save money to fund existing and necessary services. In particular, more money is required to improve teachers' salaries, to encourage new recruits and to retain current staff. It seems likely, however, that as technology becomes less costly and more efficient, new ways will be found to reduce the resources spent on labor intensive services.

The reluctance of teachers to become actively involved in new technologies is perhaps the biggest obstacle to overcome (Pogrow, 1983; Griffin, 1983) for at least two reasons. First, school organizations are, in general, slow to change. Second, the application of technology to education has not proved to be consistently effective in the past, nor has it altered the educational structure significantly. Teachers remember past efforts to encourage use of programmed instructional television, for example, and look with a more critical eye at current technology-based innovations. As Griffen (1983, p. 98) states:

> Methodologies for equipment use in education have often been crude. Software support has been limited, expensive, non-standard, often poorly developed, and seldom properly evaluated. Much current and past software has been created by programmers and technicians. It has had face validity and is often well packaged and effectively sold; but it has seldom been designed with a sound research or instructional design base. Again, educators have not had the time, training, resources, or inclination to develop their own material but have been forced to adopt or adapt what is available. Thus, support by education and the hardware industry have left something to be desired and has often dissipated when the next new "toy" has appeared.

The production of high quality educational software is complicated by several factors concerning the school market. Software development is costly, and a developer's return on investment depends strongly upon the size of the market and on consumer's awareness of the product's availability. To be successful, developers and publishers must be able to identify likely purchasers, and inform them about their product through advertising or direct mailings. However, as Russ-Eft and McLaughlin (1983, p. 65) have noted, the "basic characteristics of the school market are an unknown to small developers and publishers; and even when these characteristics are known, they are certain to be in a rapid state of change due to hardware and software developments and the unpredictability of teacher acceptance." Thus developers and publishers frequently incur substantial marketing costs, yet fail to market their products in a cost-effective way. As a consequence, development and marketing costs are often not recovered through product sales.

Griffen's presumption (above) that teachers would write "better" programs than programmers and technicians is a tenuous one. While their educational strategies may be more sound, their technical shortcomings may produce bugs and program weaknesses that limit usability. Teamwork between teachers and technicians seems essential, but it is costly.

The wide variety of microcomputers on the market, in particular, requires that special efforts must be made to implement software for different machines. It also means that a school may need to purchase multiple versions of the software for its different machines, if in fact those

different versions are available. Additionally, the problem of software piracy remains a significant barrier for producers and developers, although licensing agreements with schools have helped to address this issue.

## Conclusion

The existing and emerging technologies discussed in this paper have extraordinary potential for improving the quality of education. The extent to which that potential will be reached invites speculation. School systems with access to these technologies will be able to approach traditional instructional tasks with tools that permit individualization of instruction, access to information, and management of student progress to an extent heretofore unavailable. The payoff could be especially high in special education, where individualization of instruction is so important.

Our major challenge is to quickly learn how to use these tools appropriately and effectively. Considerable experimentation and innovation will be required before we discover how best to proceed. We should not be distracted from this challenge by issues of whether new technologies will be adopted by schools. Their rapid diffusion in society in general suggests that their incorporation by educational institutions (which tend to be rather slow to change) will be inevitable. Instead, it would be wisest to focus our attention on the question of how best to use these technologies in the schools and how best to manage the process by which schools accommodate them. How quickly we learn will determine how quickly our students learn.

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Appendix

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Minnesota Educational Computing
Consortium (MECC)
2520 Broadway Drive
St. Paul, MN 55113
(612) 376-1101

Resources in Computer Education (RICE)
Northwest Regional Laboratories

SpecialNet
National Assn. of State Dirs.
of Special Education
1201 16th St., N.W., Ste. 404E
Washington, DC 20036
(202) 822-7933

SOFTSWAP
San Mateo County Office of Education
333 Main St.
Redwood City, CA 94063
(415) 363-5472

Teacher Education and Computer
Centers (TECC)
Contact the Office of Staff
Development, California State
Department of Education
721 Capitol Mall
Sacramento, CA 95814-4785
(916) 322-6260

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Camera, Inc.
297 Elmwood Ave.
Providence, RI 02907